Practical instructions for the computer lab

Quantum Scattering in 3D

Before the lab

- Read the instructions carefully to make sure you understand everything. Use your course book and the lecture material as supplementary reading.
- Prepare the MATLAB m-files M1-M4 according to the instructions.
  - The template files can be downloaded from

    `http://www.isv.uu.se/thep/courses/QM/tasks/`
  - Edit them in your favorite editor to supply the missing code.
  - Make sure you have access to the files at the lab. Bring them on a USB-stick or put them somewhere on the Internet so you can download them.
- Bring your UpUnet-S student username and password **C** to be able to login.

When the lab starts

- To login in to the computers, enter your UpUnet-S student username in the form

  `user1234@student.uu.se`

  together with your password **C**.
- There are two important directories that will be used for the lab:
  - **O:\Kvantmekanik** (read-only) on the network drive contains necessary files for running the provided tasks.
  - **C:\Temp** (read-write) on the local drive where you can create *your own working directory*, e.g. **MyDirectory**, in which you should save all the files you create. An even better alternative is that you use your **student file area** to save the files for later reference.

- Put the m-files you prepared in your working directory.
- To start MATLAB , click on the icon on the desktop, or use the Windows start menu. Make sure you are running 7.
- Once you have started, type the following commands at the prompt:

  ```
  >> addpath O:\Kvantmekanik
  >> addpath C:\Temp\MyDirectory
  >> cd C:\Temp\MyDirectory
  ```

  Remember to change the two last commands to point at your chosen working directory.
  These commands will set the common path for the provided files, the path of your local working directory and it will it will move the prompt to your working directory.
- Keep in mind that you can use some UNIX commands at the prompt, to change the working directory and view its content: **pwd, cd, ls, dir, ...**
- If you need help with a Matlab command, type at the prompt **help command**, or use the Help Desk provided by Matlab from the menu
- Feel free to explore the utilities provided by Matlab. For figures, for example, in the figure window you can use the tools provided in the tool bar, such as zooming into the plots you have created, or 3D-rotating them by dragging the mouse.
- You can use the local printer to print out Matlab plots that you like (for your own use) or you feel need to be attached to the answer sheet.
- If you find the package interesting and you would like to try it at home, you can download it from the following address (on the course homepage)

  `http://www.isv.uu.se/thep/courses/QM/qmpack.zip`

- To start the package just type *qmech* at the prompt and then follow the lab instructions and your intuition.
- Be patient when the program performs calculations and rendering pictures or movies. Bear in mind the performance of the machines and the complexity of the calculations you are performing.

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Q&A sheet ‡ Name: ....

Q1.1 Which feature of the potential is affected if the parameters V_0 and W_0 are varied?

Q1.2 Which feature of the potential is affected if the parameters R and a are varied?

Q1.3 How can the potential be made to look like a spherical well with a flat bottom and a very sharp boundary?

Q1.4 What do you find for the wave number and the wavelength?

Q1.5 Compare the wavelength to the extension of the potential. Why is this an interesting thing to do? What kind of phenomena do you expect if the wavelength is about the size of the diameter of the potential well? (If you have time, you may investigate this point further in part 3)

Q1.6 If $\vec{k} = \hat{z}$ and $\vec{k}' = k \sin\theta \cos\phi \hat{x} + k \sin\theta \sin\phi \hat{y} + k \cos\theta \hat{z}$, why doesn't $f(\vec{k}', \vec{k})$ depend on the azimuthal angle ϕ?

Q1.7 Suppose it takes 1 min to get N counts in a detector at 6 degrees. How long time will it take to get the same number of counts at 60 degrees?

Q2.1 How do $j_l(x)$ and $n_l(x)$ behave when $x \to 0$ and when $x \to \infty$ (i.e. how *fast* does $j_l(x) \to 0$, etc)?

Q2.2 Which are the values of $P_l(1)$ and $P_l(-1)$? How many zeros has $P_7(x)$?

Q2.3 How many terms are necessary in order to achieve an accuracy of about 0.1% in the range $0 < x < 25$?

Q2.4 How many terms are required in order to achieve an accuracy of about 0.1% for all angles $0 < \theta < \pi$?

Q2.5 Can you judge from the plots how many partial waves will turn out significant when generating the cross section? Remember your estimate and compare with the actual result obtained later.

Q2.6 For which l-values are the phase shifts significantly different from zero?

Q2.7 Which property of the potential makes $S_l \to 1$ for large l ?

Q2.8 How do you explain that S_l never is on the unit circle, except when $S_l = 1$ for large $\boldsymbol{l}$? How would you change the potential in order to get an 'elastic window' where $|S_l| = 1$ before S_l reaches 1.

Q2.9 What could be the origin of the oscillatory behaviour at large angles?

Q2.10 What happens to the fit after the parameter change?